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EDITORIALS

The article on "The 'Seal' Theory", published in this issue, recalls to mind the fact that this theory, which is now very widely accepted, was first proposed in an article which appeared in "Lubrication" in June, 1912, entitled "Motor Lubrication, With Some Side Lights on Compression and Carbon." A great many tests have been made to substantiate this theory, and the results of these tests have proven conclusively that the Texaco Motor Oils maintain this "seal" in the highest degree. As a result, a high degree of compression is secured with these oils in use, with a consequent increase in power and decrease in the consumption of gasoline and motor oil. This is especially true of the high viscosity motor oils like Texaco Motor Oil Heavy and Texaco Motor Oil Extra Heavy. On a car with worn rings and poor compression the effects of the use of Texaco Motor Oil Extra Heavy are nothing less than astonishing.

The most recent developments in the field of handling lubricants have been in connection with cutting oils. While it will undoubtedly be some time before the majority of plants install equipment for properly filtering and sterilizing cutting oils, the progress which has already been made in developing the apparatus and in installing equipment is very gratifying to those interested in the subject of efficient lubrication. To those interested in the Safety First movement, also, the possibility of completely sterilizing cutting oils, and thus doing away with the danger of infection, the article by Mr. May and Mr. Fenno will be of special interest. In connection with this, however, we should like to call particular attention to the Texaco line of cutting oils. At the present time, we have three grades of thread cutting oil, all manufactured from the same mineral oil, the grades varying only in the amount and kind of compounding material. For practically all work these oils are superior to pure lard oil.

THE "SEAL" THEORY

By Mr. W. F. Parish

As long ago as 1911 the engineers of the Texas Company conducted an elaborate series of tests on practically all motor oils on the American market, for the purpose of establishing a basis for the production of Texaco Motor Oils. During these tests the greatest care was taken to note the changes in motor oils after a predetermined run. Comparison of the new oil with the oil removed from the crank case of the motor immediately after the completion of the test disclosed a peculiarity that had never before been noticed or mentioned by any of the investigators working with lubricating oils. In every case the oil after use was lower in flash, lower in burning point, sometimes considerably lighter in gravity, and lower in viscosity. The amount of change in these physical characteristics was invariably closely related to the original body or viscosity of the oil. The lighter the body of the oil when new, the greater the change.

There could be but two reasons for this change: decomposition of the motor oil itself, or the admixture of lighter petroleum products during the working of the motor. To determine whether or not the change was due to decomposition, long road tests were made, using benzol as motor fuel. Benzol in a petroleum lubricating oil can be very easily detected, whereas the products of decomposition in a petroleum oil are similar to gasoline, and if lighter petroleum products are found in a lubricating oil it is impossible to tell whether they came from the fuel or from the lubricating oil. The benzol test established the fact that the gas leaked past the piston rings, this gas evidently afterwards condensing and greatly affecting the motor oil. As high as three per cent. of benzol was found in the motor oil after four hours run. The effect of this benzol was to lower the flash and fire points, increase the Baumé gravity, and lower the viscosity of the original oil. This matter has been checked for several years, and much interesting and conclusive data has been secured during that time.

What takes place in the four-cycle internal combustion engine is simply this: During the compression stroke a portion of the charge of mixed gasoline and air, or "gas", is forced past the piston rings into the crank case, and the "gas" is there condensed, the gasoline mixing with the lubricating oil. This is where practically all of the lighter products found in a used motor oil come from. There are two further possibilities which may, to an extent, account for some of the lighter products getting into the motor oil, the first being the mixing of the heavy ends of the gasoline (that part which does not readily burn) with the lubricating oil on the cylinder wall, thus reducing the viscosity of the oil which, in this lower resisting state, is more easily forced down during the compression stroke; and the second being that the same heavy ends of the gasoline, not having been completely consumed, follow the power stroke, mix with the motor oil on the lower cylinder wall, and drain out into the crank case.

The following readings on a new and a used motor oil will show

clearly the effect of the loss of "seal." The samples were taken from the motor of a well known car, the car being operated by the manufacturer from his own service station with an oil bought especially for use in this particular make of car; and it may be of interest to note that this particular oil meets the specification for a proper light motor oil, issued by the Society of Automobile Engineers. Furthermore, oil of this particular character is recommended for this particular car by many of the large oil companies which publish recommendation tables of oils for various cars.

The readings of the new oil and of the same oil after a run of ten days, are as follows:

Lab. No.	27211 B	27210 B
Sample	B 6677	B 6676
Product	New	Used ten days
Gravity, Baumé	31.1°	43.3°
Gravity, Specific	.8707	.8095
Flash, open	395°F.	90°F.
Fire	455°F.	105°F.
Pour test	40°F.	Below Zero
Viscosity, Saybolt Universal at 100° F.	207 sec.	32 sec.
Color ½" cell	120	
Appearance	Red	Black
Odor	Normal	Burnt
Water	Zero	Zero
Carbon (Conradson)	0.17 Hard-Brittle	0.15 Hard-Brittle
Ash	Trace	Trace

Flash and fire tests were taken in an open cup. Pour test is the temperature at which the oil ceases to flow, as taken in a four-ounce bottle. Viscosity is taken on a Saybolt Universal Viscosimeter at 100° F.

The change in the condition of the oil is the same as shown in our records of scores of samples, though the above sample shows a greater general change in the used oil than in any sample we have ever examined. The viscosity of the used oil of 32 seconds at 100° F. is less than the viscosity of any bath spindle oil now put on the market; and a bath spindle oil is the lightest lubricating oil made. A bath spindle oil is used in a textile spinning mill; the spindle sits in a bath which holds ¼ of an ounce of oil. Further, the viscosity of 32 seconds at 100° F. is only about two seconds greater than the viscosity of water on the Saybolt Viscosimeter.

From a lubricating standpoint there is not a practical man in the oil business who would dare recommend a 32 second viscosity oil for motor lubrication, because the use of such an oil would mean practically no lubrication, considerable wear, and positive danger from bearings seizing. Due to lack of seal and consequent leakage of gas, oils of such low viscosity are being used in the motors of many of the cars on the road today, and this condition is responsible for the fast wearing out of the motors and bearings, for carbon troubles, for high gasoline and oil consumption, for loss or lack of compression and power, and for general dissatisfaction with many motors as power plants.

The method of purchasing lubricating oil is largely responsible for this state of affairs. If a new oil meets some specification or makes a good appearance in a bottle, and if the guide published by some oil company recommends the oil for a certain make of car, this oil is

purchased. Probably only the practical minded pay even this much attention to the subject, most motorists accepting whatever oil is offered to them. The fact remains that in most motors the oil changes completely, and, with the majority of oils, the change occurs within a few hours, until it is no more like the original oil than black is like white, and no one pays the slightest attention to it, or even knows that such a change has taken place.

Service stations and manufacturers work on every item about a car sent in by a complaining customer except the one vulnerable point—the condition of the motor oil in use. When a customer complains of a car as to power, compression, excessive consumption of gasoline or lubricating oil, to say nothing of carbon or burned-out bearings, scored rings or cylinders, the investigator contents himself with asking what oil was used, and then he visualizes the oil as it looks to him in a sample bottle, or according to the physical readings of a new sample.

If motor users and manufacturers would think of their motor oils on the basis of the conditions that the oil will be in while it is in actual use, a long step would be taken toward the goal of efficiency in motors. At the same time, there would be eliminated from the market many of the very ordinary oils now disposed of for this very important work of motor lubrication.

The following suggestions may prove helpful. The oil that changes least in the motor during use is the one that will give the best service, as this unchanged condition can only result from the oil itself making and holding a "seal" against the gas and heavy end leakages. Motors change with use, and if a motor oil shows thin after use, it indicates "gas" leakage, caused by inefficient sealing qualities, and a heavier oil is necessary, or one having entirely different characteristics.

It need hardly be pointed out that the flash and fire of the original oil will not serve as a guide for the oil's effectiveness. No one should make the statement that high flash or high fire test oil is a necessity for internal combustion engine work, in view of the fact that practically all oils are lowered in flash immediately after the motor is started.

The preliminary tests mentioned at the beginning of this article developed a considerable amount of data as to two points of weakness of the oils then on the market. One was the carbon-forming nature of these oils; another was the fact that they always were "shot to pieces" according to the evidence of the racing car drivers, who thus described the watery and broken down condition of the very best oils they could procure, after these oils had been given a hard run in a racing motor. This last condition, we now know, was caused by gasoline leakage.

In practical lubrication the condition of a machine or engine cannot be improved if a change is made from one oil to another of the same character and body. The oil must be of different body or must differ in its entire nature, as well as body; otherwise, there will be no mechanical results due to the change.

Working entirely with paraffine base crudes, practically the only leeway allowed the engineer was to vary the body of the oil. With oils of this crude it was soon evident that the heavier the oil in body the greater were its carbon-forming propensities. This limited the oil to the lighter runs of from 100 to 200 seconds viscosity Saybolt at 100° F., which were found to give

cleaner cylinders and valves. On the other hand, in hard running motors, such as those in racing machines, the light oils would not last long enough to allow the race to be completed, and heavier oils had to be furnished the racing teams, who had to put up with the high carbon content in order to run at all. All racing cars are furnished with the heaviest kinds of oils, sometimes much heavier than those sold to cars of the same make in ordinary service.

The Texas Company was in no way limited to the use of crude of any particular characteristics, as they had and have supplies of paraffine, semi-paraffine, and asphaltic base crudes from which to make their selection. As a result of the preliminary work on the testing block a series of oils was developed, which were a very decided novelty, as in practically every characteristic they were different from anything that had ever been produced for this service. In fact, it was very difficult to sell them at first to parties buying under specification, as in no particular were these oils the same as the paraffine base oils that formed the foundation for all specifications up to 1912.

These new oils can be varied in body over a wide range without the admixture of cylinder stocks, which is necessary in order to make heavy motor oils from other crudes. The body of the Texaco motor oils ranges from 200″ to 750″ at 100° F., and the carbon content (Gray method) from 0.06% to 0.5%. The carbon content of Pennsylvania oils ranges from 1.08% to 3.7% for practically the same range in viscosity or body. Furthermore, it developed that these new Texaco oils, due to the care in refining and manufacturing, as well as to the nature of the crude, would distill without decomposition, which is the reason for their low carbon producing nature, and which also indicates their suitability for motor lubrication. Other oils show a marked degree of decomposition under distillation.

It was only on the basis of use that these oils could be established, and our vast trade has been built up on the performance of these oils in motors of all types until today we are enjoying a well earned reputation as manufacturers of the most efficient motor lubricants now offered for sale.

In the November 1916 issue of "Lubrication" we called attention to the splendid work of the speed boat, "Miss Minneapolis", winner of the American Power Boat Association Gold Challenge Cup, 1916, and at the same time we called attention to the fact that the fastest speed boats in the world, "Miss Detroit", "Disturber IV" and "Baby Speed Demon II", as well as "Miss Minneapolis" were all lubricated with Texaco Motor Oil Extra Heavy. As a matter of fact, so many of the winners among the racing boats have used Texaco Motor Oil that this fact is in itself proof of the high degree of compression and efficiency which is secured with Texaco Motor Oil, it being quite clear that the owners of these speed boats would not buy our motor oil unless they were able to get the maximum power out of their motors by its use.

The same statement applies to the use of Texaco Motor Oil in racing cars, another extremely severe test of a motor oil. As far back as November, 1914, we published a letter from Louis Disbrow, in which he brings out very clearly the merits of Texaco Motor Oil when used for dirt track racing, conceded by racing men to be the hardest sort of conditions under which a racing car

can be operated. Many other famous drivers have used and are using Texaco Motor Oil, and they agree in the verdict that with this oil in their motors, they secure a high degree of compression. They also agree with the motor boat operators as to the almost absence of carbon deposits.

A severe test was recently made on Texaco Motor Oil Medium by Messrs. P. G. Scull and C. W. Tuthill in a winter reliability tour in a double transcontinental trip from coast to coast and back again, the details of which are of interest. These men had used Texaco gasoline and motor oil for Maxwell demonstrations in Newark for over two years, and therefore decided to use The Texas Company's products for their entire trip. Texaco Thuban Compound was used for the transmissions, differentials, and rear axles, and Texaco gasoline was used with the exception of a distance of 1,445 miles, where competitive gasolines were used.

The run started at Newark, N. J., on the morning of Thursday, November 16, 1916. The car was a 1917 stock Maxwell touring car which had been used 1,500 miles before the trip was started. Before leaving, the cylinder heads were cleaned out, the valves were ground, and a new set of spark plugs was installed. Every bearing and housing was washed with gasoline, and Texaco Grease and Thuban Compound were used as lubricants. The first day the car was driven to Wheeling, W. Va., 460 miles, the second day to Indianapolis, and the third day to St. Louis. No adjustments were made until the drivers reached St. Louis. Here the spark plugs were removed, and they were surprised to find that there was no carbon whatever on the plugs. The spark plug points were closed and from then on this was necessary about every 2,000 miles, as the points were eaten away by the hot spark. About every 700 miles the grease cups on the shackle bolts, on the generator bearing, on the fan swivel, and on the pinion thrust bearing were turned down. The shackle bolts were exposed to dust and mud all of the time, still they lasted the entire 9,615 miles.

Los Angeles, California, 3,450 miles, was reached in ten days and sixteen hours, of which six days and two hours were spent in the car. In Los Angeles, the wheels were taken off, the bearings washed, and new brake bands put on. One large inside cup for the front wheel ball bearing was replaced as it had a couple of spots of the case hardening chipped off. It would probably have gone the entire distance home, but the drivers wished to save trouble on the road. Two $\frac{3}{8}$" balls in the same bearing were also replaced. At this point they tried to get some Thuban into the differential but it was up to the overflow plug, none of the original supply having been used up. The supply in the transmission also needed no replenishing, there being as much in the case as when the start was made, and all gears as well as the lubricant were in fine condition. The drivers here changed from cup grease in the universal joint and steering head to Thuban Compound.

In San Francisco what little carbon there was was cleaned out, the valves ground, and the oil drained out of the crank case. Though 4,000 miles had been covered there was hardly any carbon and the valves scarcely needed more than touching up. Mr. Scull, calling attention to the steep hills in the city of San Francisco, said "Grades of thirty per cent. are quite common and they use cable street cars and

have them so arranged that when one goes up another comes down. We never imagined that an automobile could go up these hills, but the Maxwell's sales manager took us up in a Maxwell, so we thought his demonstrator 'some' car. However, we were following him later in the day over those same hills on our way to have a photograph taken, and our 'old boat' could trim his in any speed, and he thought that it was some recommendation for Texaco oil and gasoline."

After spending some time around Los Angeles, the return trip was started. At El Centro they reached the Yuma Desert, 100 feet below the level of the sea. For seventy-five miles nothing could be seen but sand, and in places it had drifted 30 to 40 feet high. Across the worst section a plank road has been built, but the rest of the way the drivers had to follow the ruts which were so deep that the engine pan was continually hitting. After leaving Yuma at the eastern end of the desert the drivers had what they called "the worst 175 miles of hard road in America." They found it impossible to describe the ruts and the deep holes in the ruts, all covered with from six to eight inches of light, feathery dust, which came up through the boards, nearly choking them.

Tucson, Arizona, was reached on Christmas Day. At El Paso the drivers commenced a test of other makes of gasoline. Across the flat parts of Texas where the roads were very good they averaged about 17.5 miles per gallon on this competitive gasoline. This was three or four miles less than they had obtained on Texaco gasoline under worse conditions. Over their total of 7,197 miles up to the point where they reached El Paso, they had averaged 20.2 miles per gallon of Texaco gasoline.

The run to Dallas, Texas, a total distance of 7,700 miles, was made without a bearing adjustment. Here a small leak in the crank case was discovered caused by hitting bottom in the ruts. This, of course, had caused the loss of considerable motor oil.

Near Shreveport, La., they struck the red clay roads, and as there had been a great deal of rain and sleet the roads were worse than ever. It was necessary to run in second speed a great deal of the way from there to New Orleans and up to Washington. Beyond New Orleans there were long stretches through the swamp where they forded water to the hubs, also places filled in spots where the car sank to the hubs in mud. The motor was turning over at from 1,000 to 1,500 revolutions in low speed for long distances, a pretty severe test on the motor oil.

The total trip from New York to San Francisco and back was 9,615 miles. The condition of the car after the trip was better than before. On a level road it would run 34 miles per hour in second speed, and in high speed 49 miles per hour on a plank road. As Mr. Scull expresses it, "These figures tell the tale of proper lubrication."

A sample of Texaco Motor Oil M. was taken out of the car after it had returned to New Jersey and compared with the original oil. This oil was put into the car at Dallas, Texas, since which time the car has operated practically 2,000 miles. A small amount of upkeep oil was put in from time to time. The readings compared to those of new Motor Oil M. are as follows:

	New Motor Oil M	Used Motor Oil M
Lab. No.	22863B	27971B
Gravity, Baumé	21.3	22.1
Flash	345° F.	275° F.
Fire	400° F.	390° F.
Pour Test	Below Zero	Below Zero
Viscosity, Saybolt Universal at 100° F.	296 sec.	219 sec.
Color, ½" cell	150	
Appearance	Pale	Black
Odor	Normal	Burnt
Water	Zero	Zero
Carbon (Conradson)	.03%	.52%
Ash	None	Trace

It will be noted that while there is a change in the flash and viscosity, the change is not nearly so great as the difference in the readings of the paraffine oil given in the first part of this article, the paraffine oil having been in the car only ten days. The difference in the readings of these two samples illustrates quite clearly the effect of the better seal produced by Texaco Motor Oils.

IMPROVED METHODS OF HANDLING CUTTING LUBRICANTS

Systems for Automatically Circulating, Filtering and Sterilizing Cutting Oils and Compounds.

By Edwin M. May and George F. Fenno
Richardson-Phenix Co.

THE impetus which the war has given to the output of the machine shops in this country has naturally led to an investigation of

everything connected with the cost of production. In practically every shop where such an investigation has been made, it has been found that only a small percentage of the full value of the cutting lubricant is realized. In most plants the cutting lubricant is thrown away when it becomes too dirty for further use, and naturally the question arose, "Why not filter the oil and use it over again?"

It is interesting to note that as soon as the problem of improving the ways of using cutting lubricants was attacked in a scientific manner, methods were perfected and apparatus designed which resulted in a whole series of economies only suspected heretofore. These economies are now well established in the best operated shops.

With the result already obtained, it is indeed surprising that the old method of using the same cutting oil or compound over and over again, without purification, is still being used in some shops. Even where some half-hearted attempts are made to purify the cutting oil, it is often carried around in buckets and poured through inefficient filters not designed or suited for the filtration of this kind of oil. The expense and waste incurred in handling cutting oil in this manner frequently offsets its advantages.

There is no reason why methods of handling cutting oil should not be brought up to the present scientific and efficient basis of the modern automatic Oiling and Filtering Systems used on power plant machinery. These have entirely supplanted the old-fashioned hand and oil cup method of lubrication in all efficiently operated power plants and in a like manner systems for automatically handling cutting oil are rapidly superseding all other methods. The advantages of these systems are more fully pointed out below, but the most important feature to the shop owner is that they usually pay for themselves in less than a year.

Where it would be impractical to have a filter at each machine, the usual small circulating pump on each machine tool is disconnected and the filtration of the cutting oil is done on the group plan, that is, a number of machine tools are so arranged that after passing over the work the oil flows from the base of each machine through pipes or concrete trenches to the filter, where it is purified and either pumped to an overhead storage reservoir from whence it flows by gravity to the machines, or else it is pumped directly into a supply line with branch outlets leading to each of the machines. In the latter case the pressure is controlled by a relief valve, so that a predetermined head will at all times be available at the outlets. Motor driven triplex pumps are usually used when pumping direct to the machines, and either these, rotary, or centrifugal pumps may be employed when an overhead gravity supply system is installed.

When machines are grouped in various parts of the shop, it is often most economical to use a comparatively small central filtering system for each group or department. A typical Richardson-Phenix filter for this service is shown in Fig. 1. Dirty oil from the machines flows in through the three inlet pipes, down through the chip baskets which are made of fairly coarse screen and intended to remove the largest particles of foreign matter, thence under the separating partitions into the filtering compartment. After passing through the filtering units the purified oil flows into the clean oil compartment. The rotary pump either elevates the oil to an over-

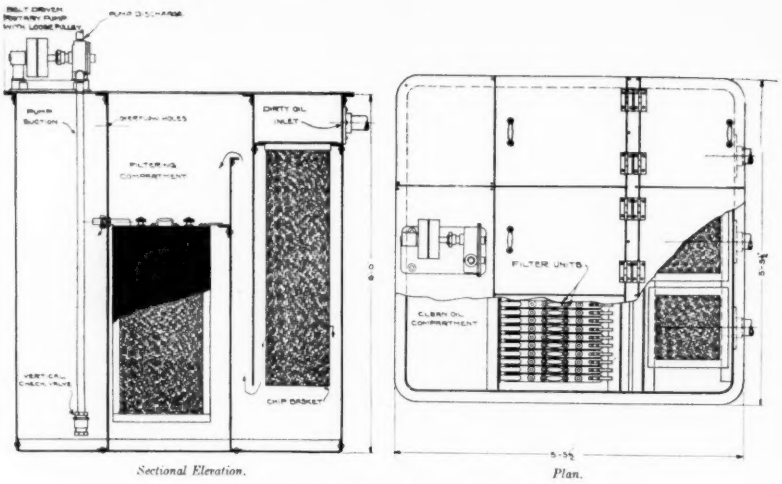

Figure 1—Peterson Cutting Oil Filter

head reservoir or pumps against a relief valve into the distributing system. This filter is known as the Peterson type and is very similar to the filter described in the September issue of "Lubrication", except that the precipitation compartment is omitted.

While as stated above the primary object of filtering cutting oil was to reduce the oil bill, other advantages have resulted which in many cases are more important than the saving in oil. These advantages are summarized below, most of them being self-evident.

(1) The elimination of scale, sand, and chips from the cutting oil prevents the tools from becoming dull resulting in (a) decreased power consumption, (b) increased life of tools, (c) reduction in the loss of operators' and machine time due to sharpening, (d) higher operating speed, (e) increased accuracy.

(2) Oil is returned to the tools at a lower temperature which (a) increases the lubricating and cooling value of the oil, (b) decreases its tendency to oxidize and gum and to hold chips in suspension, (c) reduces the fire hazard and consequently reduces the insurance rate.

(3) In many plants the filters, oil pumps and storage tanks are located in a separate fireproof vault, the only oil in the plant being the comparatively small amount in the piping system which is fully enclosed.

(4) As the same oil is used over and over again, a high grade oil can be employed which will not foam or rust the work and which will afford better lubrication for the machine slides and bearings.

(5) An automatic system saves the labor of carrying oil to and from the machines.

(6) It saves the oil wasted in filling and emptying containers and machines.

(7) It increases the cleanliness of the plant as no oil is spilled.

(8) The use of a large number of circulating pumps on each machine is eliminated.

With the advent of employers' liability laws in so many states, sterilization of cutting oils and compounds is now being seriously considered. It has been found that

bacteria will accumulate in oils and compounds and cause serious trouble by infecting the operators with blood-poisoning; in fact, instances have been recorded where infectious diseases have been communicated from one employee to another. Attempts have been made to sterilize cutting oil by mixing an antiseptic compound with the oil, but this method has been discarded because of the high cost of the compound or its effect on the metal or oil.

Interesting laboratory experiments made by the Richardson-Phenix Company on a large number of samples taken from well known industrial plants showed that if the oil is maintained for a period of 20 minutes at a temperature of about 140° F., all harmful bacteria are destroyed. The results of some tests of a fairly typical cutting oil are as follows:

The sample to be tested was divided into four portions which after being filtered were treated as follows:

The oil before treatment contained 24 bacteria per 1 cc. of oil.
The oil heated for 20 minutes—

At 80° F.	contained	24	bacteria per 1 cc.	of oil.
At 100° F.	"	15	" " 1 cc.	"
At 120° F.	"	8	" " 1 cc.	"
At 140° F.	"	no	" " 1 cc.	"

The counts were made on each sample after incubation of 48 hours, at 37° C. after each heat treatment, there being no growth in the portion heated at 140° F. after incubating for 48 hours at 37° C.

You will note that the original dirty oil showed a bacteria count of 24 per cc. and that the three samples which were heated for twenty minutes at temperatures of 80°, 100° and 120° F. were not properly treated to kill all of the bacteria, but that treating the oil at 140° F. seemed to free the oil from all bacteria.

In order to check up this last treatment, samples of the oil that had been treated at 140° were set aside and allowed to incubate for 24, 48, 76, 96 and 120 hours. These samples, which were examined after every twenty-four hours, showed no trace of bacteria, and it is safe to assume that if after 120 hours no growth appeared, all of the bacteria had been killed.

Another interesting fact is that after the oil is thoroughly sterilized it can be safely used for from one to two weeks, depending on shop conditions, without further treatment.

Therefore, in a central circulating and filtering system it is not necessary to sterilize the oil continuously. This fact is fortunate, because it would be almost impracticable to continuously heat the oil for sterilization. It would also have to be cooled again before being suitable for re-use on the tools. The method now generally resorted to is to sterilize the oil about once a week either in the filter or in a separate sterilizing tank.

When sterilization is required, the batch filter, as shown in Fig. 2, is usually employed. This is very similar to the batch type turbine filter described in the September issue of "Lubrication", except that a large heating coil is provided in the top or receiving compartment. The method of operating a filter of this type is as follows: For ordinary continuous filtration the used oil flows into the top or receiving compartment through the filtering units into the clean oil compartment, from whence it is returned to the distributing pipes. The opera-

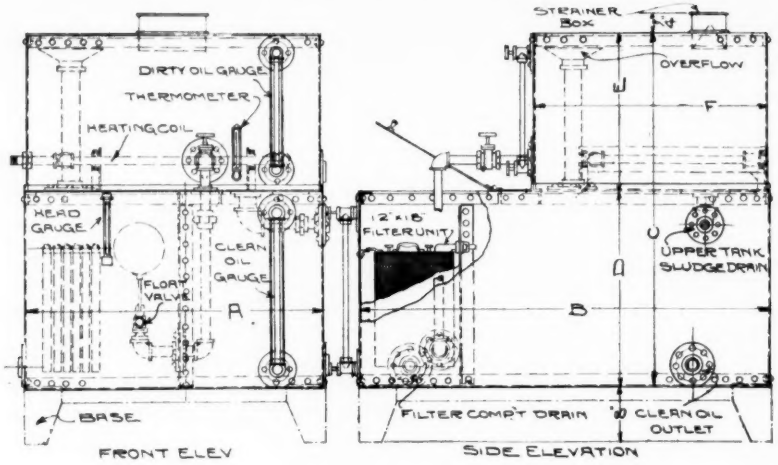

Figure 2—Batch Filter

tion is exactly the same as the filter shown in Fig. 1. Sterilization is usually accomplished on Saturday afternoon or Sunday. All of the oil from the machines and piping system is allowed to drain into the top compartment of the filter. The heat is turned on and the oil allowed to come up to the sterilizing temperature. The most frequent practice is to put a moderate size heating coil in the top compartment and to allow the oil to flow through the filtering units into the clean oil compartment, from whence it is pumped again to the top compartment. In this way the oil is kept circulating over the heating coils which greatly increases their efficiency, and at the same time the oil is given a thorough filtration, because it passes through the filtering medium many times during the process of sterilization.

To sum up the advantages of filtering cutting oil in the words of Mr. J. A. McClean, General Manager of the Boss Nut Company of Chicago, where a Richardson-Phenix Central Cutting Compound System was installed just a year ago:

"The production of our punch presses has been increased approximately twenty-five per cent.

"Taps and dies are giving longer periods of service between grindings.

"There is a pronounced reduction in the use of compound, due to the fact that all of it, except what adheres to the nuts, is returned through the drains provided for that purpose, and used over again.

"Increased cleanliness throughout the shop, due to the elimination of the compound dripping on the floor around the punch presses and the further elimination of all of the individual pumps, which were formerly used on our tapping machines. These pumps constantly leaked and were a source of continual annoyance to us. This one feature is responsible for the saving of a great deal of the compound.

"Naturally, in view of what your system has accomplished, as shown above, there has resulted a pronounced reduction in our manufacturing costs."